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LEAF ANATOMY OF *JUBAEOPSIS CAFFRA* BECC.

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Abstract

The anatomy of the lamina and leaf sheath of *Jubaeopsis caffra*, an endemic palm from the east coast of South Africa, was studied. Observations were recorded and comparisons were made with other cocosoid species. Generally the leaf anatomy of *J. caffra* was found to be similar tc that of most other cocosoid genera, but a few distinguishing differences were noted. The most significant of these is in respect of the anticlinal walls of the adaxial epidermis cells. These cell walls are sinuous and distinguish *Jubaeopsis* from all cocosoid genera except *Orbignya*. Further, the margins of the leaflets are slightly ribbed. This is in contrast to the other cocosoid species where no marginal rib is present.

Uittreksel

BLAARANATOMIE VAN *JUBAEOPSIS CAFFRA* BECC.

Die anatomie van die lamina en blaarskede van *Jubaeopsis caffra*, 'n endemiese palm vanaf die Suid-Afrikaanse ooskus, is ondersoek. Waarnemings word beskryf en 'n vergelyking met ander cocosoide spesies word gemaak. Oor die algemeen stem die blaaranatomie van *J. caffra* ooreen met die meeste ander cocosoide genera, maar 'n paar uitstaande kenmerke is waargeneem. Die belangrikste hiervan is ten opsigte van die antiklinale wande van die adaksiale epidermisselle. Hierdie selwande is gekartel en onderskei *Jubaeopsis* van alle ander cocosoide genera behalwe *Orbignya*. Verder, is die rande van die blare effens gerib. Dié is in teenstelling met die ander cocosoide spesies waar geen marginale rib aanwesig is nie.

Introduction

Tomlinson's (1961) classic work on the anatomy of the palms deals so completely with the literature on this subject that it would be superfluous to give a complete review thereof here. Although Tomlinson does describe the anatomy of the cocosoid palms in general and that of a number of genera in particular, no information concerning the anatomy of *Jubaeopsis caffra* is available. In view of this it was felt that a study of the anatomy of this species would be justified.

Although the leaf, stem and root were examined, it is the anatomy of the leaf, and in particular that of the lamina, which exhibits by far the most diagnostic features (Tomlinson, 1961). Consequently only data relating to the anatomy of the lamina and leaf sheath are presented in this paper.

Material and Methods

All the plant material used in this study was collected from trees in the *Jubaeopsis* groves on the estuary of the Mtentu river in Pondoland on the east coast of South

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Africa. Fixation of the material was in formaldehyde/ethyl alcohol/acetic acid (Sass, 1958).

Dehydration was accomplished with a graded tertiary butyl alcohol (TBA)-ethyl alcohol series while infiltration with wax was achieved by using a graded TBA-paraffin wax series. The material was embedded in paraffin wax (Carowax; melting point 54-58 °C).

Sections were cut on a rotary microtome at a thickness of 10 μm. These were stained with safranin and counterstained with fast green (Brooks, Bradley & Anderson, 1950; Holtzhausen, 1972).

Material used in the SEM study was air-dried and coated with palladium-gold (Robbertse, 1974) prior to viewing in a Jeol JSM-U3 microscope.

Although some sections of *Jubaea* material were made, the comparisons of *Jubaeopsis* with *Jubaea* and other species are discussed mainly on the basis of Tomlinson's (1961) descriptions of these species.

RESULTS

Lamina

The mesophyll is clearly demarcated into adaxial palisade tissue and abaxial spongy parenchyma and consequently the leaf of *J. caffra* is dorsiventral (Fig. 1).

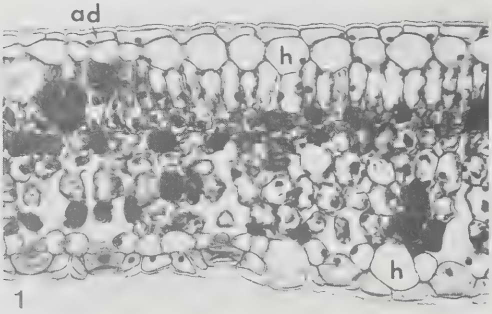


FIG. 1.
Longitudinal section of the leaflet lamina of *J. caffra*. ×150.
(Ad—adaxial epidermis; h—hypodermis).

Thin flakes or layers of wax occur on the surface of the leaflets (Fig. 2) but only a small amount of wax is present.

Epidermal hairs also occur on both surfaces. These hairs consist of a larger, thin-walled sunken basal cell and four or five thin-walled distal cells arranged radially around the distal tip of the basal cell (Figs 3 & 4). These hairs are restricted to the intercostal regions. A second type of epidermal appendage occurs in the form of scale-like outgrowths along the midrib.

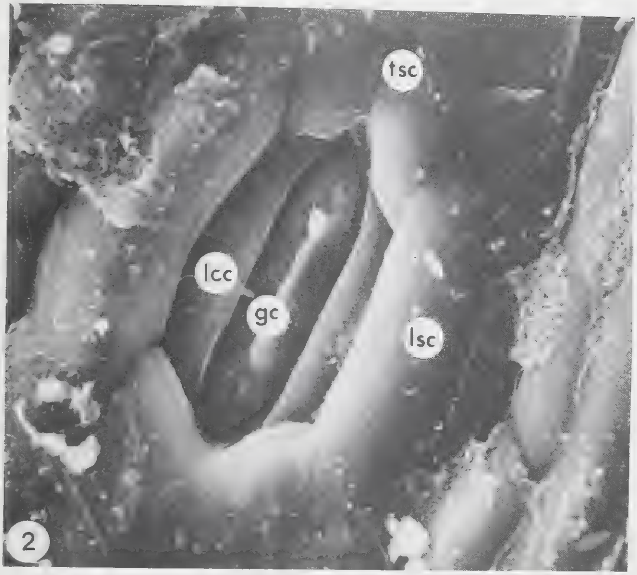


FIG. 2.
Stereoscan micrograph of stoma. ×1000.
(gc—guard cell; lcc—lateral contact subsidiary cell; lsc—lateral subsidiary cell; tsc—terminal subsidiary cell).

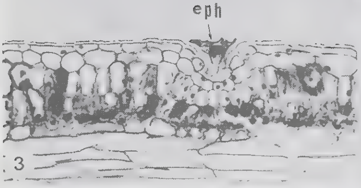
The adaxial surface is covered by a thick cuticle while that on the abaxial epidermis is slightly thinner (Fig. 1). The cuticle is smooth and has no characteristic features or patterns, except on the guard cells. (These cells are discussed later).

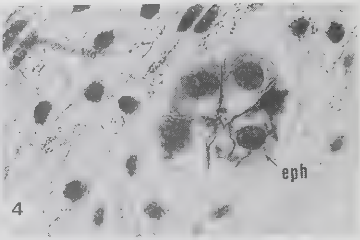
Along the leaflet margins and on the adaxial side of the midrib the cuticle is particularly thick (Figs 6, 7 & 10).

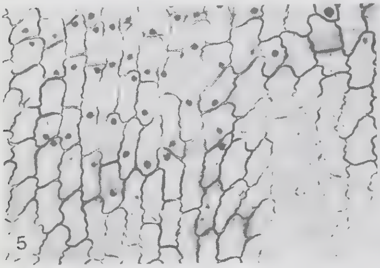
In *J. caffra* the outer tangential walls of the epidermis cells are largely cutinised and are thick (Figs 1, 3, 6–8, 10, 11) especially in the case of the adaxial epidermis and in the vicinity of the midrib and margin. The cell walls are however not lignified. While the tangential or anti-clinal cell walls of the adaxial epidermis appear somewhat sinuous in a surface view (Fig. 5) those of the abaxial epidermis are only slightly sinuous to non-sinuous (Figs 12 & 13).

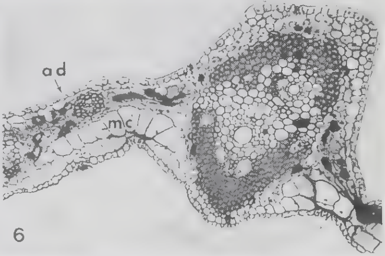
Adaxially no costal and intercostal bands are distinguishable, but abaxially the epidermis cells of these two regions differ mainly in respect of size with the costal cells slightly larger and broader than the intercostal epidermis cells (Fig. 12). The costal bands are narrower than the intercostal ones (Fig. 12).

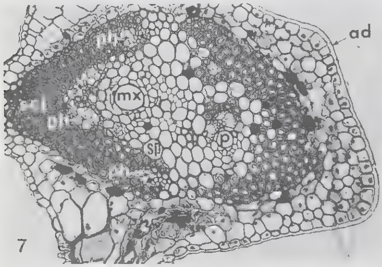
The cells of the epidermis are longitudinally extended but are rather shallow (Figs 1, 3, 11 & 12). Around the leaf margin and the midrib however, the











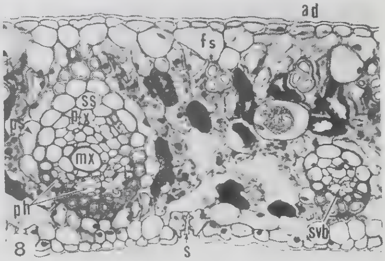


FIG. 3.

Longitudinal section through a portion of the lamina showing an adaxial epidermal hair (eph). ×150.

FIG. 4.

Surface view of the epidermal hair (eph). ×400.

FIG. 5.

Surface view of the adaxial epidermis of the leaf. ×180.

FIGS 6 & 7.

Transverse section through leaflet midrib. ×60; ×150 resp. (ad—adaxial surface; mc—motor or expansion cells; mx—metaxylem; p—peripheral bundle; ph—phloem, sch—sclerenchyma; sp—sclerotic parenchyma).

FIG. 8.

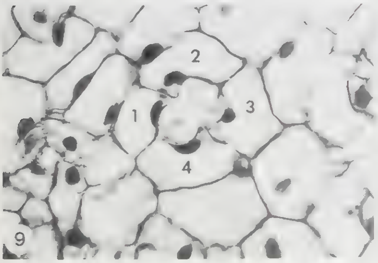
Transverse section through lamina. ×150. (ad—adaxial surface; fs—fibrous strands; mx—metaxylem; ph—phloem; ps—parenchymatous sheath; px—protoxylem; rs—raphide sac; s—stoma; ss—sclerenchymatous sheath; svb—small vascular bundle).

epidermis cells are uniformly isodiametric (Figs 7 & 10). The abaxial epidermal cells over the hypodermal expansion or motor cells on either side of the midrib are distinctly papillose (Fig. 6).

The stomata are restricted to the abaxial surface and specifically to the intercostal bands where they are very numerous (Fig. 12). The stomatal complex found in this species appears to be similar to that described by Tomlinson (1974) for *Cocos* and other Palmae, viz. a complex which originates from non-intersecting oblique divisions in the neighbouring cells. Each stoma is surrounded by six subsidiary cells (Figs 2 & 13). Two of these are terminal subsidiary cells and are short, thin-walled kidney-shaped cells (Figs 2 & 13) which are not sunken (Fig. 2). The two lateral contact cells are very narrow cells with the non-contact walls, i.e. walls not in contact with the guard cells being thickened (Fig. 13). These cells are distinctly sunken and envelope the guard cells (Figs 2, 8 & 14). The remaining two large lateral subsidiary cells are not sunken (Figs 2 & 14). The guard cells, which are sunken (Figs 2, 8 & 14) are small and thin-walled and are provided with a prominent outer and slightly less prominent cutinised ledge (Fig. 14).

A hypodermis of large cells occurs beneath both the adaxial and abaxial surfaces. In each case only a single layer of hypodermal cells occurs (Fig. 1 & 8) except in the vicinity of the margin and the midrib (Figs 6, 7, 10 & 11). Cells of the hypodermal layers are thin walled. The shape and size of the adaxial and the abaxial hypodermal cells tend to be irregular (Figs 8 & 12). In the abaxial hypodermis the intercostal hypodermis cells are somewhat larger than the costal hypodermis cells (Figs 8 & 12).

Each substomatal chamber is surrounded by four L-shaped abaxial hypodermis cells (Fig. 9).



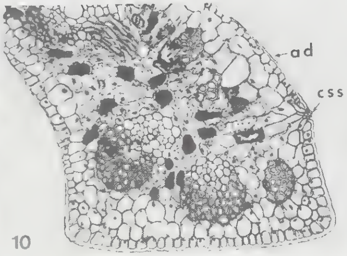


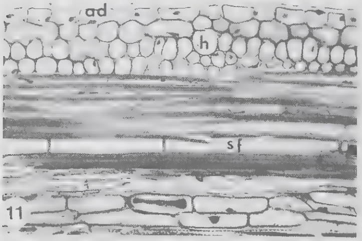
FIG. 9.
Paradermal section through abaxial hypodermis of the leaf showing four L-shaped cells (1–4) around the sub-stomatal chamber. ×360.

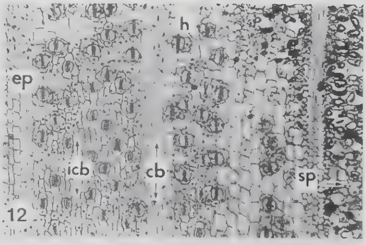
FIG. 10.
Transverse section through the leaf margin. ×90. (ad—adaxial surface; css—connecting strip scar.)

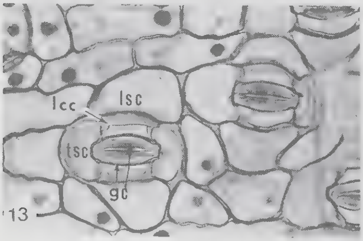
The chlorenchymatous mesophyll is clearly demarcated into an adaxial palisade tissue and abaxial spongy parenchyma (Fig. 1).

Generally only one or two layers of palisade cells are present. In a surface view the palisade cells which appear more or less circular, are densely packed into neat longitudinal files between the strands of fibres which run parallel to the long axis of the leaflet (Fig. 15), while the cells of the spongy parenchyma are extended transversely (Fig. 16) at right angles to the axis of the leaflet.

Three types of idioblasts occur in the mesophyll, viz. (i) a large number of tanniniferous cells, (ii) raphide-sacs and (iii) silica cells or stegmata. The tanniniferous cells occur throughout the parenchymatous tissues of the lamina and leaf







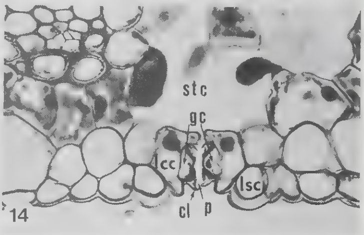
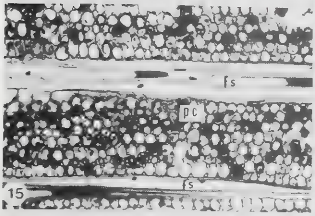


FIG. 11.
Longitudinal section through leaflet midrib. ×150. (ad—adaxial surface; h—hypodermis; sf—septate fibres).

FIG. 12.
Oblique surface section through the abaxial epidermis of the lamina. ×60. (cb—costal band; ep—abaxial epidermis; h—hypodermis; icb—intercostal band; sp—spongy parenchyma).

FIG. 13.
Surface view of the abaxial surface of the lamina showing the organisation of the stomatal components. ×360. (gc—guard cells; lcc—lateral contact cell; lsc—later subsidiary cell; tsc—terminal subsidiary cell).

FIG. 14.
Transverse section through a stoma. ×360. (cl—cuticular ledge; lcc—lateral contact cell; gc—guard cells; lsc—lateral subsidiary cell; p—pore; stc—substomatal chamber).



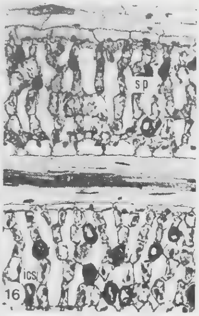


FIG. 15.
Paradermal section through the lamina of a leaflet, showing the closely packed chlorenchyma and fibrous strands. ×160. (fs—fibrous strands; pc—palisade chlorenchyma).

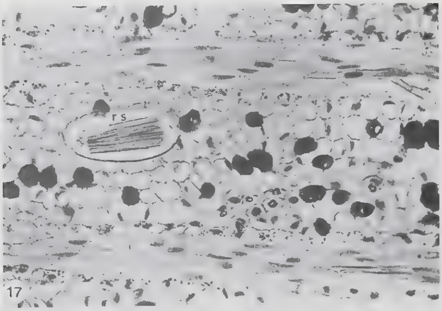
FIG. 16.
Paradermal section through the abaxial portion of the lamina, showing the transversally extended spongy parenchyma cells. ×160. (ics—intercellular spaces; sp—spongy parenchyma).

sheath. Sacs containing raphide clusters occur as large cells elongated parallel to the long axis of the leaflets (Figs 8 & 17). Each cell contains a bundle or sheaf of needle-like crystals which are embedded in densely staining mucilage. With regard to the stegmata, the silica bodies in cells are spherical. Although these cells are numerous, they are found only in association with vascular bundles and fibrous bundles. The stegmata occur in single longitudinal files around these bundles (Fig. 18). The walls of the stegmata are slightly lignified and very often these cells occur in depressions in the walls of the fibres.

Numerous non-vascular fibres are present in the lamina. These occur singly and in groups or strands and are situated mainly beneath the adaxial hypodermis (Fig. 8). Only a small number of fibrous strands occur abaxially. In a transverse section these fibrous strands are small and consist mainly of between one and six fibres. At the margin however, the fibrous bundles are much thicker (Fig. 10). These fibres are thick-walled, septate (Fig. 15) and often unlignified.

The venation of the lamina is parallel and includes longitudinal veins of various sizes connected by transverse commisures (Fig. 19). Basically two sizes of veins occur (excluding the midrib). The largest of these, which often contains a single large metaxylem vessel, is more or less centrally situated in the mesophyll and is connected to the epidermis by a fibrous sheath. The small vascular bundles on the other hand are restricted to the abaxial mesophyll and connected to the abaxial surface only (Fig. 8).

The large vascular bundles are sheathed by an outer parenchymatous layer and an inner sclerotic layer. The outer sheath is uniseriate and consists of large,



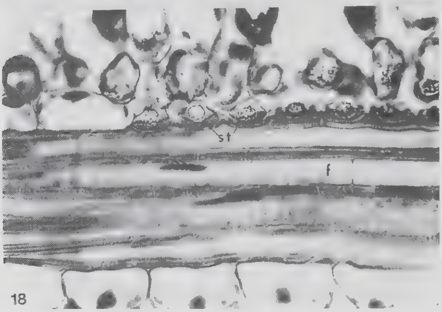


Fig. 17.
Paradermal section through the lamina showing a raphide sac (rs) in the mesophyll. ×230.

Fig. 18.
Longitudinal section through lamina showing stegmata and silica bodies associated with fibres. ×570. (f—fibres; st—stegmata with spherical silica bodies).

vertically extended (in a transverse section) parenchyma cells containing only a small number of chloroplasts. This sheath usually occurs only laterally to the vein and is often absent from the adaxial and abaxial regions (Fig. 8). The inner sheath is multiseriate and is comprised of fibres and sclerotic parenchyma, the fibres being limited mainly to the adaxial zone (Fig. 8). These fibres are lignified and are easily distinguishable from the adaxial fibre buttresses which connect the veins with the adaxial hypodermis. The outer sheath of the small veins is not well differentiated. The inner sheath is also somewhat reduced and consists adaxially of a single layer of sclerotic parenchyma and abaxially of two or three layers of fibres.

The xylem consists mainly of protoxylem vessels and xylem parenchyma. It is normally very difficult to distinguish between these tissues and the sclerenchymatous sheath, especially in the small veins, when viewed in transverse section. The larger veins however normally contain a single large metaxylem vessel which is easily distinguishable (Fig. 8).

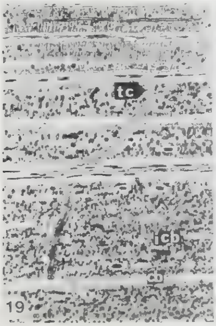
The phloem occurs abaxially in the vascular bundles. It is separated from the xylem by at least one cell layer of sclerenchyma (Fig. 8). Normally the phloem, which includes sieve tubes, companion cells and phloem parenchyma is divided into more than one group in the midrib only, but not in the other veins (Figs 6–8 & 10).

The midrib is adaxially very prominent (Fig. 6). As mentioned earlier, the epidermis cells are fairly uniform, but the abaxial ones are somewhat smaller than the adaxial epidermis cells, and the adaxial cuticle is thicker than that of the abaxial surface (Fig. 7).

Adaxially the hypodermis of the midrib is multiseriate and comprises three layers of large parenchyma cells (Figs 6, 7 & 11). Abaxially, the hypodermis cells are small in the centre of the rib, but are laterally confluent with the expansion cells and thus increase in size on either side of the midrib (Figs 6 & 7).

In the midrib there is a thick multiseriate fibrous cylinder surrounding the central ground tissue. This cylinder is composed of two crescent-shaped sections, one adaxially and the other abaxially orientated. Where these two sections join, i.e. more or less across the middle of the midrib (in transverse section) the cell walls are somewhat thinner (Figs 6 & 7).

The central ground tissue, which consists mainly of sclerenchymatous tissue or sclerotic parenchyma, envelops the vascular bundles. A large vascular bundle is situated abaxially and consists of xylem (with a single large metaxylem vessel)



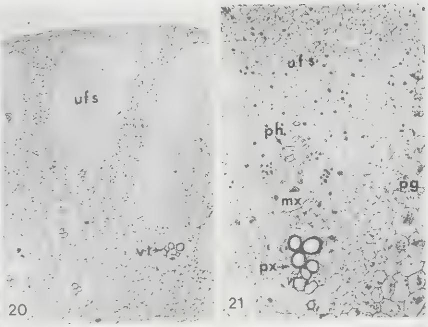


FIG. 19.
Paradermal section of leaflet in which transverse commisures are evident. ×25. (cb—costal bands; icb—intercostal bands; tc—transverse commisures).

FIGS 20 & 21.
Transverse section through the dorsal portion of the spear-leaf sheath. ×25; ×160 resp. (mx—metaxylem; pg—starch-rich parenchymatous ground tissue; ph—phloem; px—protoxylem; ufs—undifferentiated fibrous sheath or cap; vt—vascular tissue).

and three or four small groups of phloem separated from each other and from the xylem by partitions of sclerenchyma. A second, smaller vascular bundle is adaxially situated, but is of a more compact nature (Figs 6 & 7). Peripheral vascular bundles do occur in the midrib (Fig. 7) but are rare.

Two abaxial bands of expansion cells occur in the leaflet. These are present as bands on either side of the midrib and run parallel to the midrib (Fig. 6). They consist of one or two hypodermal layers of very large, colourless parenchyma cells which occupy more than half the depth of the lamina. Although the two bands are confluent with the hypodermis of the midrib the cells of the midrib hypodermis are not differentiated into expansion cells. No fibrous strands occur within these bands.

Although the lamina of cocosoid palms does not normally have a well-differentiated margin, that of *J. caffra* is rather prominent (Fig. 10). The cuticle, epidermis and hypodermis in this region are very similar to those of the midrib. Further, the veins in the margin possess very thick abaxial fibrous caps. The epidermis of the lamina is interrupted at a point near the margin by the "scar" left by the connective strip which connects the leaflets of the lamina with each other in the developing leaf (Fig. 10).

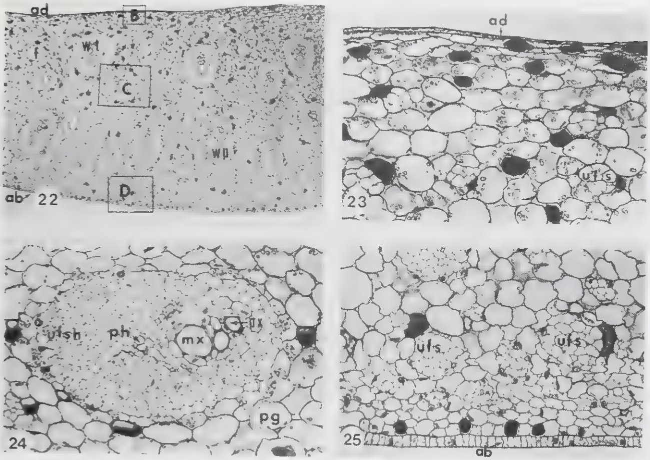
Leaf sheath

The sheath of the spear leaf, i.e. the oldest, unopened leaf, is still meristematic and consequently it is largely parenchymatous and no sclerotic tissue has differentiated at this stage (Fig. 20). However, associated with each vascular bundle is a group of cells which are much smaller in diameter than the cells of the surrounding parenchymatous ground tissue (Figs 20 & 21).

These cells constitute undifferentiated fibres which, after differentiation, give the sheath its tremendous strength and durability. The peripheral bundles in the dorsal section of the sheath are associated with exceptionally large, fibrous caps (Fig. 20). In the spear leaf the vascular tissue in the leaf sheath consists of protoxylem, one group of phloem per bundle and vascular parenchyma. Differentiation of metaxylem is initiated at about this time (Fig. 21).

The cells of the ground tissue are very rich in starch (Figs 21 & 23).

In the sheath of the youngest expanded leaf, the cells are also still mainly unlignified and no sclerenchyma is evident (Figs 22–25). The adaxial cells of the ventral section however, become tangentially elongated, probably as the result of the expansion in diameter of the stem (Fig. 23). Apart from the group of undifferentiated fibres associated with the vascular bundles, numerous strands of undifferentiated non-vascular fibres become evident. Although these are scattered throughout the ground tissue (Figs 22 & 25) they are concentrated in the abaxial peripheral region (Fig. 25). At this stage each vascular bundle consists of a large undifferentiated fibrous sheath, a number of protoxylem vessels, a single large metaxylem vessel, two groups of phloem and vascular parenchyma (Fig. 24).



FIGS 22–25.
Transverse section through the ventral portions of the sheath of the youngest expanded leaf.

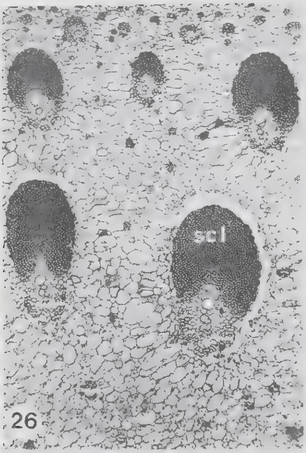
FIG. 22.
×25.

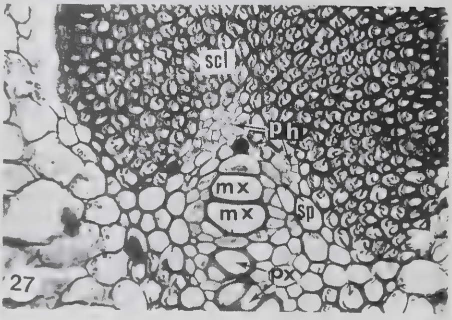
FIG. 23.
Portion B of Fig. 22. ×160.

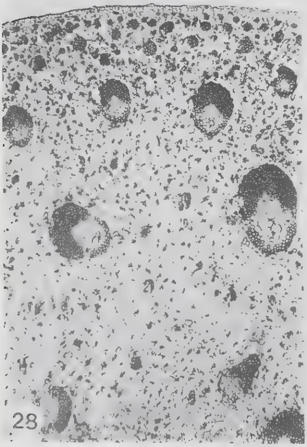
FIG. 24.
Portion C of Fig. 22. × 160.

FIG. 25.
Portion D of Fig. 22, showing the peripheral fibrous bundles (still unsclerified) in the abaxial portion of the leaf sheath. ×160.
(ab—abaxial surface; ad—adaxial surface; f—"filling" fibrous strands; mx—metaxylem; pg—parenchymatous ground tissue; ph—phloem; px—protoxylem; ufs—unsclerified fibrous strand; ufsh—unsclerified fibrous sheath; wp—"warp" vascular bundles; wt—"weft" vascular bundles).

As the leaf matures, sclerification of the fibres takes place and each vascular bundle is associated with a large sclerotic cap (Fig. 26). The number of metaxylem elements increases, but still only two groups of phloem are present. Further, a large amount of sclerotic parenchyma occurs in the vascular bundles (Fig. 27). In a longitudinal section through the ventral tissues of the sheath, the vascular bundles are not perfectly vertical but are arranged at a slight angle to the left and right. The adaxial bundles which constitute the "weft", are angled upwards from right to left on the one side of the ventral line and from left to right on the opposite side of this line. The abaxial bundles, i.e. the "warp" on the other hand, are orientated in precisely the opposite manner. The type of leaf sheath found in







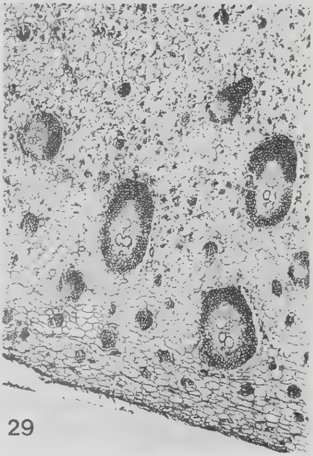


FIG. 26.

Transverse section through the ventral tissues of the sheath of a mature expanded leaf, showing the extent to which the fibrous sheath or phloem cap becomes sclerified. ×25. (scl—sclerenchyma).

FIG. 27.

Enlargement of one of the vascular bundles in Fig. 26. ×160. (mx—metaxylem; ph—phloem; px—protoxylem; scl—sclerenchyma; sp—sclerotic parenchyma).

FIG. 28.

Transverse section through the abaxial ventral tissues of a mature leaf sheath showing the "warp" vascular bundles. ×25.

FIG. 29.

Transverse section through the adaxial vascular bundles of the same leaf as in Fig. 28. These bundles constitute the "weft". ×25.

Jubaeopsis caffra is intermediate between the *Phoenix* and *Cocos* types (Robertson, 1977). As can be seen from Figs 28 and 29, there is very little difference in thickness and the extent of sclerification between the warp and weft bundles. The numerous, non-vascular fibrous bundles constitute the ''filling''. (The terminology used here is that proposed by Tomlinson, 1964).

DISCUSSION AND CONCLUSIONS

The dorsiventrality of the leaf of *J. caffra* is in accordance with the majority of other cocosoid genera.

The epidermal hairs which occur on the leaf of *J. caffra* are similar to those of *Orbignya*, *Elaeis* and *Syagrus* in that they consist of a single inflated, distinctly sunken basal cell and a number of thin-walled distal cells, but differ from those of *Jubaea* in which the basal cell is not sunken and from those in *Cocos* where three or four basal cells occur.

As far as the adaxial epidermis of the leaf is concerned, *J. caffra* differs from all the cocosoid palms except *Orbignya*, in that the anticlinal cell walls are sinuous. Further, *J. caffra* differs markedly from *Jubaea* in that the adaxial epidermis cells of the former species are longitudinally elongated, while in the latter case, the cells are transversely elongated (Tomlinson, 1961).

As in other cocosoid genera, the stomata of *J. caffra* are restricted to the intercostal bands of the abaxial surface. The stomatal complex of *J. caffra* is similar to that described by Tomlinson (1974) for *Cocos nucifera*. According to Tomlinson (1961) the guard cells are not sunken, except in *Scheelea* and *Syagrus yatay*. In this respect *J. caffra* is similar to the latter two cases in that the guard cells are distinctly sunken (Figs 2 & 13).

Both the adaxial and abaxial hypodermis layers of *J. caffra* are only one cell layer thick (Fig. 1). In this respect it is similar to *Elaeis* and *Orbignya*, but dissimilar to *Cocos* which has an adaxial hypodermis of one or two cell layers. *Jubaea* on the other hand has a well-developed adaxial hypodermis, consisting of three cell layers while a single cell layer occurs beneath the abaxial epidermis.

The chlorenchyma of most cocosoid palms is usually demarcated into distinct adaxial palisade layers and abaxial spongy parenchyma. *J. caffra* leaves exhibit the same structure and differ thus from *Jubaea* in which no spongy parenchyma occurs. The entire mass of chlorenchyma in the leaf of this latter genus consists of palisade tissue (Tomlinson, 1961).

Orientation of the fibrous strands in the leaf of *J. caffra* is similar to the majority of genera in this sub-family in that they occur mostly as adaxial, sub-hypordermal strands with only a few abaxial strands. Again, *J. caffra* differs quite markedly from *Jubaea* which has very few non-vascular fibrous strands.

Similarly, *J. caffra* differs from *Jubaea* but is basically similar to the majority of cocosoid genera in respect of the orientation of the veins in the lamina. Generally the large vascular bundles in most genera are centrally placed in the mesophyll and have contact with both surfaces, while the smaller vascular bundles are abaxially situated and are connected to the abaxial surface only (Fig. 8). In *Jubaea* (Tomlinson, 1961) on the other hand, all the vascular bundles, irrespective of size, are in contact with both surfaces via fibrous buttresses.

In *J. caffra* three to four groups of phloem occur in the larger vascular bundles. These are separated from each other by strips of sclerotic parenchyma which radiate from the metaxylem vessel. In this respect it is similar to *Cocos, Coroza, Attalea, Elaeis* and *Maximiliana* (Tomlinson, 1961) but differs from *Jubaea* in which the number of phloem groups often exceeds four and which are separated by both vertical and horizontal sclerotic partitions.

The most significant difference between the midrib of *J. caffra* and that of *Jubaea* is to be found in the chlorenchyma. In *Jubaea* the central sclerotic cylinder of the midrib is surrounded by well-developed peripheral chlorenchyma which is continuous with that of the lamina. However, in *J. caffra* very little assimilatory tisssue is present in this region (Fig. 7).

It appears that all cocosoid genera (except *Maximiliana*) have two abaxial bands of expansion cells—one on either side of the midrib of the leaflet. The composition of these bands though, is not the same in all genera. In *J. caffra*, for example, the bands consist of between one and two cell layers only (Fig. 7) while in *Jubaea* the equivalent cells are smaller, but between three and four cell layers are present.

Although Tomlinson (1961) states that the margins of the leaflets in cocosoid genera are not ribbed, *J. caffra* has a rather prominently developed margin, consisting of two to three hypodermal cell layers, two vascular bundles and a fibrous bundle. In this respect *J. caffra* is quite similar to the caryotoid palms which have distinct marginal ribs (Tomlinson, 1961).

The only detailed description of a cocosoid leaf sheath is of *Cocos nucifera* (Tomlinson, 1964). It would seem from the results of this study that the anatomy of *J. caffra's* sheath is very similar to that of *C. nucifera*, except that there is little difference between the adaxial and abaxial bundles, i.e. weft and warp respectively, in *J. caffra.*

The general conclusions that can be drawn from this study are that although the anatomy of *J. caffra* is basically similar to the majority of other cocosoid palms, it does have certain distinguishing features. The most important of these being the sinuous anticlinal walls of the adaxial epidermis cells and the presence of a marginal rib.

Anatomically, the leaf of *Jubaeopsis* differs very markedly from that of *Jubaea* and the relationship between these two monotypic genera is perhaps not as close as suggested by Beccari (1913).

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